System Dynamics at Cornell: Vision and Barriers

System dynamics deal with how things change through time, which includes most of what most people find important.
Jay Forrester, Professor Emeritus, MIT Sloan School of Management

System dynamics is the use of computer simulation for policy analysis in complex systems.
George Richardson, Rockefeller School of Public Policy, SUNY-Albany

Background and Justification

Changes in technology, population and economic activities are transforming our world. These changes result primarily from our own actions (and interactions), and create both challenges and opportunities. When change results in outcomes considered undesirable, our efforts to address these problems have often proved ineffective or even harmful. The last half-century has witnessed tremendous growth in the number of advocates of "systems thinking" as a more appropriate way to address these problems System dynamics (SD) is the broadly applicable approach to problem solving that underlies "systems thinking". Using SD, a real-life problem can be expressed as a feedback model that can help us better understand how a problem developed over time, and assist us in finding a lasting solution to the problem.

SD, although applied primarily to social systems, is grounded in the theory of nonlinear dynamics and feedback control developed in mathematics, physics and engineering. SD is inherently interdisciplinary but also provides tools that can improve disciplinary perspectives on particular issues. SD methods recognize that the real world is a nonlinear web of feedback processes with significant delays, and is usually not in equilibrium. SD is problem focused, requiring its practitioners to seek the causes of problems in the interactions of real-world feedback loops. SD provides a way-of-thinking (a paradigm) and associated communication and computer simulation tools, to help design policies that provide durable solutions to important problems.

Since February 2000, the number of Cornell faculty and students interested in learning about system dynamics (SD) has grown. This is due in large part to the presence of Paul Newton, a M.Phil. student pursuing a degree in SD at the University of Bergen in Norway. Paul came to Cornell to work with the faculty and staff of the Department of Applied Economics and Management (AEM) on research to understand the sources of price volatility in US dairy markets. Through Paul's work, a number of other faculty, staff, and students have become interested in applying SD methods to research questions, and faculty already aware of SD have come in contact with one another. With limited resources, individual faculty members and students have supported and participated in activities to learn about SD. These include the group use of MIT distance education programs for SD, three non-credit introductory short courses taught at Cornell (two in 2001, and one in 2002), and the development of a SD discussion group for interested students and faculty. Currently, in CALS there are three faculty, three research

associates, nine graduate students, two post-doctoral fellows, and one visiting scholar who are using SD in research projects. The research projects are diverse, ranging from structural change in US agriculture to water allocation in the Peruvian highlands We are aware that SD seminars have been held in the Hotel School, and understand that SD is being used in the JGSM, the College of Engineering, and Human Ecology.

Much has been accomplished in a short time with limited resources. However, Cornell alumnus Allen Boorstein ('47) has suggested that an organizational framework and additional resources would promote greater awareness of SD in the Cornell community, and would support more rapid and efficient application of SD methods. The purpose of this concept note is define a long-term vision for SD at Cornell, and describe barriers to the use of SD in the Cornell community. Subsequent concept notes will discuss suggested actions to address these barriers. Members of the Cornell community will benefit from system dynamics both through the development of additional systems thinking skills, and an improved ability, using system dynamics simulation, to address important problems close to home and around the world.

Long-term Vision for System Dynamics at Cornell

The long-term vision is that SD will be used at Cornell, when appropriate, in research, instruction, outreach and administration.

In general, problems that are appropriate for the application of SD methods include those that are dynamic (change over time), involve feedback, and can be described by a relatively small set of "reference mode" behaviors over time.

Goals for Awareness and Application of System Dynamics at Cornell

1) Introduce Cornell Students, staff, faculty, and administration to system dynamics.
2) Assist Cornell faculty and staff in the application of SD in their **research**, especially interdisciplinary, problem-oriented projects.
3) Assist Cornell faculty with incorporation of SD into **education**, either as part of existing courses or as entirely new courses.
4) Assist Cornell faculty and staff in the application of SD in extension and other **outreach** activities, including business, agriculture, government, communities and K-12 education.
5) Assist Cornell **administration** in the application of SD to policy design for the University and other administrative units (colleges, schools, departments).
6) Facilitate greater understanding of the relationships between SD and other modeling paradigms in common use, including the characteristics of problems for which SD is best suited. That is, help interested parties choose appropriate methods to address a particular problem.
7) Facilitate dissemination of information about advances in SD methods and applications, and the exploration of other evolving methods that address the essential characteristics of systems behavior (e.g., agent-based modeling).

Current Barriers to Use of SD at Cornell

Limited awareness of SD Methods. Few programs at Cornell offer instruction in SD, and even those employing SD principles sometimes do not use the term "system dynamics." Thus, there are few faculty, staff and students aware that SD exists.

Lack of a community of SD practicioners. Without a core group of faculty, students and staff with knowledge of SD, it is more difficult for individuals who become aware of SD to learn enough for its effective application.

Limited opportunities to learn about SD. Although a few courses at Cornell use SD methods, there is no single course devoted to SD methods. More generally, there are few on-campus resources available to support individuals who want to learn and apply SD methods.

Lack of incentives for faculty, students, staff and administrators to learn and apply SD. Faculty currently stand to gain little in terms of project funding or professional recognition from the use of SD methods in fields where SD is not commonly known. Therefore, they have little incentive to learn SD and(or) incorporate it into their teaching activities. Administrators often have few incentives to modify standard operating procedures.

Disciplinary and administrative barriers to funding for SD projects. Because SD is not broadly known in the academic and funding agency communities, projects proposing to use SD methods may not be viewed favorably by project proposal review panels (compared to projects proposing to use methods better known in a particular discipline). Moreover, SD-based projects also face the common challenges to funding interdisciplinary versus disciplinary research work.

Fundamental barriers to learning in complex systems. In addition to the above, John Sterman at MIT notes a number of barriers to learning about complex systems.

Next Steps

Dr. Charles Nicholson (Applied Economics and Management), Dr. Alice Pell (Animal Science) and Dr. Marcy Rosenkrantz (University Library System) now administer the Boorstein Fund for System Dynamics, which supports efforts to address short-run needs for individuals interested in learning and applying SD in research projects. This project includes continuation of an SD working group, development of a SD seminar series, additional SD short courses, and outside "mentoring" support for individuals currently using SD in research. These activities are designed to support SD learning until a more comprehensive range of activities (such as faculty hires and larger-scale research projects) can be put into place. [See Status Report document for further information]. As more Cornell faculty and students become aware of and use SD, it will be necessary to develop a more detailed concept note describing a set of activities to address the barriers to use of SD at Cornell. This concept note will be developed by a broad constituency at Cornell, including faculty, research staff, extension staff (especially those with an interest in K-

12 education), graduate students, undergraduate students, in coordination with Alumni Affairs and Development.